## OPERATING INSTRUCTIONS FOR

# PEM-9004

## Portable Emissions Analyzer

P/N MPEM9004

ECO: XX-XXXX

| DANGER |
| --- |
| Toxic gases may be present in this monitoring system.<br>Personal protective equipment may be required when servicing this instrument.<br>Hazardous voltages exist on certain components internally which may persist for a time even after the power is turned off and disconnected.<br>Only authorized personnel should conduct maintenance and/or servicing. Before conducting any maintenance or servicing, consult with authorized supervisor/manager. |

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**Warranty**

This equipment is sold subject to the mutual agreement that it is warranted by us free from defects of material and of construction, and that our liability shall be limited to replacing or repairing at our factory (without charge, except for transportation), or at customer plant at our option, any material or construction in which defects become apparent within one year from the date of shipment, except in cases where quotations or acknowledgements provide for a shorter period. Components manufactured by others bear the warranty of their manufacturer. This warranty does not cover defects caused by wear, accident, misuse, neglect or repairs other than those performed by Teledyne or an authorized service center. We assume no liability for direct or indirect damages of any kind and the purchaser by the acceptance of the equipment will assume all liability for any damage which may result from its use or misuse.

We reserve the right to employ any suitable material in the manufacture of our apparatus, and to make any alterations in the dimensions, shape or weight of any parts, in so far as such alterations do not adversely affect our warranty.

**Important Notice**

This instrument provides measurement readings to its user, and serves as a tool by which valuable data can be gathered. The information provided by the instrument may assist the user in eliminating potential hazards caused by his process; however, it is essential that all personnel involved in the use of the instrument or its interface, with the process being measured, be properly trained in the process itself, as well as all instrumentation related to it.

The safety of personnel is ultimately the responsibility of those who control process conditions. While this instrument may be able to provide early warning of imminent danger, it has no control over process conditions, and it can be misused. In particular, any alarm or control systems installed must be tested and understood, both as to how they operate and as to how they can be defeated. Any safeguards required such as locks, labels, or redundancy, must be provided by the user or specifically requested of Teledyne at the time the order is placed.

Therefore, the purchaser must be aware of the hazardous process conditions. The purchaser is responsible for the training of personnel, for providing hazard warning methods and instrumentation per the appropriate standards, and for ensuring that hazard warning devices and instrumentation are maintained and operated properly.

Teledyne Analytical Instruments, the manufacturer of this instrument, cannot accept responsibility for conditions beyond its knowledge and control. No statement expressed or implied by this document or any information disseminated by the manufacturer or its agents, is to be construed as a warranty of adequate safety control under the user's process conditions.

# Specific Model Information

It is not recommended that this instrument be used for analysis on any other gas or gas mixture than that specified at the time of purchase. Using this instrument to analyze any other gas mixture may result in serious error. Consult the factory for additional information for gas analysis not specified at the time of purchase.

**Instrument Serial Number: _____**

# Important Notice

The PEM-9004 is a gas analysis computer for measuring and computing the concentration of various gases in a combustion process. Both toxic and combustible gasses may at times be present in and around the analyzer. This instrument is designed to safely handle specific combustible gas mixtures as outlined in the product specification. Since Teledyne cannot control the end use of this instrument, it is the responsibility of the user to establish whether or not the total system of instrument, environment, alarm components, and any other relevant devices actually will assure safety under the particular circumstances of use.

Location of the equipment and sensors that will insure proper operation is the responsibility of the user.

The safety checklist outlined below is only a guide. It is up to the user to establish practical safety precautions given his/her own specific circumstances. *It is vital that the operator understand and test the operation of the total system.*

## Safety Checklist

- ❑ Verify that the instrument is powered correctly.
- ❑ Verify that the instrument works properly (all functions).
- ❑ Verify that measured values are correct.
- ❑ Verify that unauthorized personnel cannot tamper with the instrument or its auxiliary equipment.
- ❑ Institute routine test/calibration procedures.
- ❑ Identify and handle any potential problems in sampling or location.
- ❑ Train all operators to understand all operations and functions of the analyzer and the system.
- ❑ Identify and handle any environmental or other influences that could affect the operation of the instrument.

## Safety Messages

Your safety and the safety of others is very important. We have provided many important safety messages in this manual. Please read these messages carefully.

A safety message alerts you to potential hazards that could hurt you or others. Each safety message is associated with a safety alert symbol. These symbols are found in the manual and inside the instrument. The definition of these symbols is described below:

**GENERAL WARNING/CAUTION**: Refer to the instructions for details on the specific danger. These cautions warn of specific procedures which if not followed could cause bodily Injury and/or damage the instrument.

**CAUTION:** HOT SURFACE WARNING: This warning is specific to heated components within the instrument. Failure to heed the warning could result in serious burns to skin and underlying tissue.

**WARNING:** ELECTRICAL SHOCK HAZARD: Dangerous voltages appear within this instrument. This warning is specific to an electrical hazard existing at or nearby the component or procedure under discussion. Failure to heed this warning could result in injury and/or death from electrocution.

*Technician Symbol:* All operations marked with this symbol are to be performed by qualified maintenance personnel only.

No Symbol

*NOTE:* Additional information and comments regarding a specific component or procedure are highlighted in the form of a note.

**CAUTION:** **THE ANALYZER SHOULD ONLY BE USED FOR THE PURPOSE AND IN THE MANNER DESCRIBED IN THIS MANUAL.**

**IF YOU USE THE ANALYZER IN A MANNER OTHER THAN THAT FOR WHICH IT WAS INTENDED, UNPREDICTABLE BEHAVIOR COULD RESULT POSSIBLY ACCOMPANIED WITH HAZARDOUS CONSEQUENCES.**

This manual provides information designed to guide you through the installation, calibration operation and maintenance of your new analyzer. Please read this manual and keep it available.

Occasionally, some instruments are customized for a particular application or features and/or options added per customer requests. Please check the front of this manual for any additional information in the form of an Addendum which discusses specific information, procedures, cautions and warnings that may be peculiar to your instrument.

Manuals do get lost. Additional manuals can be obtained from Teledyne at the address given in the Appendix. Some of our manuals are available in electronic form via the internet. Please visit our website at: www.teledyne-ai.com.

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# DANGER
## COMBUSTIBLE GAS USAGE WARNING

**It is the customer's responsibility to ensure safety especially when combustible gases are being analyzed since the potential of gas leaks always exist.**

**The customer should ensure that the principles of operating of this equipment is well understood by the user and that the instrument as well as any approved support equipment is properly installed. Misuse of this product in any manner, tampering with its components, or unauthorized substitution of any component may adversely affect the certification and the safety of this instrument.**

**Since the use of this instrument is beyond the control of Teledyne, no responsibility by Teledyne, its affiliates, and agents for damage or injury from misuse or neglect of this equipment is implied or assumed.**

# Introduction

## 1.1 Overview

The Teledyne Analytical Instruments (TAI) Model PEM-9004 Gas Analysis Computer is a multifunction analyzer with integrated calculating functions. The system is ideally suited for monitoring heaters, exhaust lines, and other flue gas installations.

The PEM-9004 analyzes the gaseous products of a combustion process and provides critical information on the state of the effluent stream. Information is available on-screen and via printed reports. Data can also be output to a remote device via the USB communication port. The system is battery operated, lightweight yet rugged so it can be moved and rapidly setup at any location.

The analyzer measures and displays the $O_2$, CO, and with the appropriate option, $SO_2$, and NO content of a gas. It also senses and measures draft or pressure and the gas temperature at the sampling point as well as the ambient temperature. An internal database of common fuels supplies thermodynamic data for calculations that the monitor performs on the sampled data, to determine the $CO_2$ and $NO_x$ concentrations when equipped with the appropriate optional sensors. The instrument also calculates combustion efficiency, excess air and other parameters critical in assessing efficiency in a combustion process.

Measured data and test results can be stored in a 100 record database for later recall and printed on demand from the monitor's integral printer. Data can also be monitored remotely via an integral USB communications port. Numerical data can be output in a variety of units for customer reports.

Gas and electrical ports along with the display and all operator controls are accessible from the front panel.

Table 1-1 and 1-2 highlight the PEM-9004 monitoring capability. They show the actual measured parameters and derived (calculated) values respectively.

*Table 1-1: Measurement Capabilities of the PEM-9004 Analyzer*

| | | | |
|---|---|---|---|
| **Measured Values** | T.Gas | Waste or flue gas temperature | °F or °C |
| | T.Room | Air or ambient temperature | °F or °C |
| | O2 | Oxygen content | % Volume |
| | CO | Carbon monoxide | ppm-mg/$mm^3$-mg/kWh |
| | NO | Nitrogen monoxide (option) | ppm-mg/$mm^3$-mg/kWh |
| | SO2 | Sulphur dioxide (option) | ppm-mg/$mm^3$-mg/kWh |
| | Draft | Draft or Pressure | inches of $H_20$ (iWC) |

*Table 1-2: Parameters Calculated by the PEM-9004*

| | | | |
|---|---|---|---|
| **Calculated Values** | CO2 | Carbon dioxide | % Volume |
| | CO 0% | Carbon monoxide, undiluted | ppm |
| | Effi. | Combustion efficiency | % |
| | Ex.air | Excess air value | |
| | qA | Waste gas losses | % |
| | Dewpnt | Fuel specific dewpoint | °F or °C |
| | T.Diff | Differential temperature (TG-TA) | °F or °C |
| | NOx | Nitrogen oxides (option) | ppm-mg/$mm^3$-mg/kWh |
| | NOx ref. | Nitric oxides, undiluted (option) | ppm |
| | SO2 ref. | Sulphur dioxide, undiluted (option) | ppm |

## 1.2 Features

- **Analysis Ranges:** The PEM-9004 is available with the following analysis ranges:
  - $O_2$ 0-20.9%
  - CO 0-4000 ppm (with $H_2$ compensation)
  - $CO_2$ (calculated from $O_2$ measurement) 0-$CO_2$ max (fuel specific)

  And optionally:
  - CO 0-2% (0-20,000 ppm) (without $H_2$ compensation)
  - NO 0-2000 ppm (optional)
  - $SO_2$ 0-2000 ppm (optional)
  - $NO_2$ 0-200 ppm
- **CO Sensor Protection:** The PEM-9004 incorporates a special CO sensor protection feature utilizing a separate pump that automatically flushes the CO sensor when an upper CO threshold of 4000 ppm is exceeded.
- **Pressure/Draft Measurement**: A piezoresistive pressure sensor with internal temperature compensation is installed for measuring pressure up to ± 60 inches of water (iWC). A convenient port is located on the front panel for positive or negative pressure measurements.
- **Temperature Measurement:** Both ambient and gas temperatures up to 1850°F (1000°C) are monitored using K-type (NiCr-Ni) thermocouples. These parameters are used by the internal processor in calculating combustion efficiency, waste gas loses, excess air and undiluted CO concentration.
- **Waste Gas Sampling:** Via an external water separator and filter, the waste gas is fed to the sensors by means of a gas feed pump. It accepts either a one point measurement probe (combi-probe) or multi-point measurement probe (multi-hole probe).

- **Unit Conversion:** Gas, temperature and pressure information is displayed and/or stored in several different units depending on the user's preference.
- **Internal Infrared Thermal Printer:** The PEM-9004 is equipped with a printer for immediate hard copy of data. If desired, the printed reports can contain a header with the company name or other convenient designation.
- **Display:** Hi-res LCD module with 5 or 10 line text and graphical display plus menu line.
- **Data Communication:** USB interface. Optional radio-interface (Bluetooth).
- **Memory:** 100 memory blocks max. including dynamic memory management and directory/file structure.
- **Power:** NiCd battery 6V/4Ah with external power adapter and charger. Integral power management system controls battery charging and prolongs battery life.

## 1.3 Operator Interface

All user controls and connections are accessible from the front panel after opening the top case. Figure 1 shows the front panel of the PEM-9004. There are 3 function buttons and 7 menu select buttons (also referred to as keys) which control all operations of the analyzer. Chapter 4 describes in detail the use of the menu select and function buttons in operating the analyzer. In addition to operator controls, gas and thermocouple ports are installed and clearly identified on the front panel.

# Operational Theory

## 2.1 Introduction

The PEM-9004 uses state-of-the-art sensor technology for accurate measurements of $O_2$, $CO/H_2$, CO-high and optionally, NO and $SO_2$. The sensors employed are electrochemical cells specific for each component.

The instrument will measure and display the actual gas concentration for $O_2$ and $CO(H_2)$. Depending on the options selected at the time of purchase, the PEM-9004 can also measure and display the NO, CO (high), and $SO_2$ concentration of a flue gas. The analyzer, based on measurements of draft pressure, temperature, and data entered for the combustion fuel plus pertinent thermodynamic data internally stored as part of the instrument's database, will calculate and display the following combustion related information:

- $CO_2$ concentration
- Non-diluted CO concentration
- Pressure and temperature differential
- Efficiency (Eta)
- Waste gas losses (qA)
- NOx concentration
- Dew point
- Eta combustion value

## 2.2 Sensor Cell

At the heart of the analyzer are the sensors. Up to 5 sensor cells are installed depending on the options selected at the time of purchase. Each cell is specific to a particular gaseous component.

## 2.3 Specific Sensor Network

The sensors employed in the PEM-9004 operate according to Faraday's Law of Electrolysis: In an electrochemical cell, the rate at which gas is produced at one pole is directly proportional to the quantity of electric current flowing through the electrodes. Conversely, the current produced by the cell is directly proportional to the consumption of gas at the pole.

The PEM-9004 incorporates a network of up to five individual sensors for analyzing oxygen, carbon monoxide, and optionally, sulphur dioxide, and nitrogen oxides. The individual sensors are arranged on a sensor block located underneath the front panel of the unit. Each sensor produces an output current proportional to the consumption rate of the particular gas for which it is sensitive. Typically, the sensor output is in the microampere range. Cross-sensitivity between sensors is measured and corrected for, using an internal algorithm. The sensor output is fast and stable and only mildly affected by changes in relative humidity or temperature.

## 2.4 Combustion Efficiency

The PEM-9004 measures oxygen, combustion gas temperature, draft pressure and ambient air temperature, and it contains an internal database of the thermodynamic properties of several common fuels. It uses these to calculate combustion efficiency as follows:

### *2.4.1 Calculating the $CO_2$ Composition of Exhaust Gas*

It first calculates the $CO_2$ composition of the exhaust gas on a dry basis using data extracted from the selected fuel. The following equation is used to calculate the $CO_2$ concentration in volume %.

$$CO_2 = CO_{2MAX} \times \left(1 - \frac{O_2}{20.9}\right)$$

Where: $CO_{2MAX}$ is the fuel specific theoretical maximum $CO_2$ concentration in volume %

$O_2$ is the measured oxygen concentration in volume %

20.9 is the oxygen content in air (volume %).

### 2.4.2 Calculating the Waste Gas Loss

The analyzer uses the measured oxygen concentration and the exhaust gas and ambient temperature of the stack to calculate the total energy loss in the exhaust gas. The total energy loss is calculated by adding in the work done to expand the exhaust gas against atmospheric pressure and the heat required to vaporize the water generated in the burning process.

The waste gas loss calculation involves multiplying the heat capacity of each component by the difference in temperature between ambient air and exhaust gas. The following equation is used to calculate the waste gas loss (qA) in %:

$$qA = (T_{gas} - T_{air}) \times \left( \frac{A2}{21 - O_2} + B \right)$$

Where: $T_{gas}$ is the waste/flue gas temperature in °F or °C

$T_{air}$ is the combustion ambient temperature in °F or °C

A2 and B are fuel-specific factors stored internally in the PEM-9004 database.

### 2.4.3 Calculating the Combustion Efficiency

The combustion efficiency of a combustion process is determined from the relation:

$$Efficiency = (E_{fuel} - E_{lost})\ 100$$

The instrument subtracts the waste gas loss as previously calculated for a specific fuel from the total energy of the selected fuel to arrive at the overall combustion efficiency (Eta). The PEM-9004 uses the following equation:

$$Eta = 100 - qA$$

Where: Eta is the combustion efficiency expressed as a percentage.

qA is the heat loss calculated for the given fuel.

The calculation is done on a dry basis. This means that the term representing the energy necessary to heat the water vapor from ambient to exhaust temperature is omitted.

To obtain the precise value for combustion efficiency one must account for many variables. The most important are:

- Radiative heat losses
- Variation in fuel composition
- Air that leaks into the flue gas mixture raising oxygen reading
- Heat loss in ash
- Incomplete combustion
- Boiler blowdown.

The PEM-9004 necessarily makes simplifying assumptions in its determination of efficiency. Therefore it must be considered a trend indicator that will correctly show an increase or decrease in efficiency, whereas the absolute value of the number applies to the ideal case only.

### *2.4.4 Calculating Excess Air Value (Lambda)*

The minimum amount of air that supplies sufficient oxygen for the complete combustion of a fuel is referred to as the theoretical or *stoichiometric* amount of air. Most combustion processes involve an amount of air different than stoichiometry requires. The differential is called *excess air* and can be a positive or negative amount. The stoichiometric requirement for air depends on the type of fuel used and to a lesser extent, the temperature and pressure of the reaction. Nitrogen is normally considered unaltered in lower temperature reactions and simply adds to the heat balance of the combustion process. As the combustion temperature increases however, increasing amounts of nitrogen oxides are formed which must be considered in the overall chemical balance.

In the PEM-9004, the excess air (Lambda) value is calculated from the ratio of $CO_{2max}$ to $CO_{2observed}$ as follows:

$$\text{Lambda} = \frac{CO_{2MAX}}{CO_2} = \frac{20.9}{20.9 - O_2}$$

### *2.4.5 Calculating Undiluted CO Concentration*

To calculate the uncompensated CO concentration the PEM-9004 uses the excess air as calculated above and the hydrogen compensated value sensed by the CO electrochemical cell to arrive at an undiluted CO concentration in ppm. The following equation is used:

$$CO(0\%) = CO \times Lambda$$

Where: Lambda is the excess air as calculated above.

## 2.5 Sample System

The built-in sample system on the PEM-9004 can be though of as a fully integrated data acquisition system. In addition to sampling the gas stream and safely diverting a portion through the analyzer, it also gathers data on pressure, temperature of the gas stream, and ambient temperature.

The sample system is comprised of the following sections:

- sample probe
- sample and CO sensor protect pumps
- gas conditioning section
- temperature and pressure measurement

The probe is a steel tube connected to several feet of neoprene tubing. It samples the exhaust gas stream and directs a portion into the analyzer via the neoprene tubing. Integral with the sample probe are 2 type K (NiCr-Ni) thermocouples, one which measures the gas stream temperature at the tip and the other sensing the air or ambient temperature. A piezioresistive element is also contained within the probe for converting pressure of the gas to an electronic signal used by the microprocessor to determine the gas or draft pressure.

Waste gas is sampled through the probe and drawn into a filter section in the analyzer by means of an 0.8 lpm pump through the Gas In port on the front panel. Figure 2-4 shows the sample conditioning section of the PEM-9004.

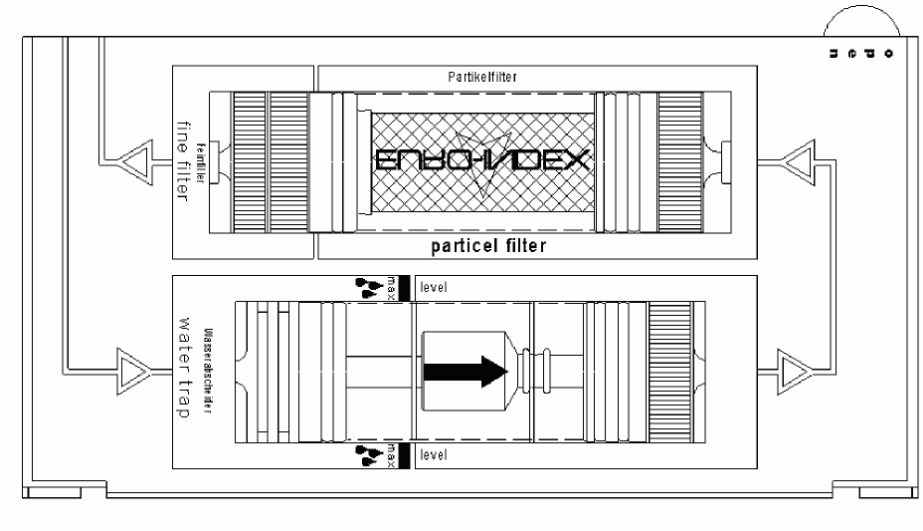



*Figure 2-4: Gas Conditioning System*

The gas is passed through a condensation trap to remove moisture which would otherwise interfere with the measuring process.

**CAUTION: THE WATER TRAP SHOULD BE EMPTIED AFTER EACH USE. IF WATER IS ALLOWED TO COLLECT IN THE TRAP IT COULD BACK FLOW INTO THE GAS LINE AND DAMAGE THE PUMP AND SENSORS.**

The sample gas is then drawn through a coarse particle filter in series with a fine filter to remove any solid residue from the combustion process prior to directing the gas to the sensor block.

The gas is fed to the sensor cells which are arranged in series. The cell outputs a signal proportional to the concentration of the specific gas it is sensitive to. Three to five cells are installed depending on the options installed. A special purge line equipped with a separate pump is installed to protect the CO sensor from prolonged exposure to high concentration of oxygen such as atmospheric air. The pump is activated automatically when the concentration exceeds 4000 ppm. It can also be operated manually. See Section 4.5.1.13 *CO Protect*.

After traversing the sensor block, the sample gas is passed back out through the Gas Out port on the front panel of the instrument.

**CAUTION: BOTH TOXIC AND FLAMMABLE GASES ARE PRESENT IN THE SAMPLE SYSTEM—INCLUDING THE FILTERS! MAKE SURE THE EXHAUST LINE IS**

**CONNECTED TO THE GAS OUT PORT AND VENTED PROPERLY.**

**USE CAUTION WHEN CHANGING FILTER ELEMENTS OR OTHERWISE OPENING ANY PORTION OF THE SAMPLE SYSTEM. ALWAYS PURGE THE SAMPLE SYSTEM TO REMOVE ANY TOXIC OR FLAMMABLE GAS FROM THE LINES BEFORE PERFORMING ANY MAINTENANCE ON THIS INSTRUMENT.**

# Installation

Installation of the analyzer includes:

1. Unpacking the system
2. Connecting the Probe
3. Making the gas and thermocouple connections
4. Calibration and testing the installation

Also covered in this section are battery issues, and information regarding battery replacement.

## 3.1 Unpacking the Analyzer

The TAI PEM-9004 Portable Emissions Monitor is generally shipped fully functional and ready to work. Carefully unpack the analyzer and inspect it for damage. Immediately report any damage to the shipping agent. Note the probe and connectors and make sure there is no shipping damage.

## 3.2 Attaching the Probe and Thermocouples

All connections are made on the front panel. Figure 2-1 illustrates the front panel and identifies the connector locations.

- Connect the exhaust gas thermocouple jack to the port labeled T Gas
- Connect the ambient air thermocouple jack to the ambient air port connector
- Connect the gas line from the probe to the gas port
- Connect the pressure sensor line to the port labeled P+ which is the port for measuring a positive pressure.

*NOTE: If you are monitoring a process which is below atmospheric pressure, connect the pressure sensor to the P- port.*

- Connect the gas out port to a suitable vent.

**WARNING: TOXIC AND FLAMMABLE GASES ARE PRESENT IN THIS INSTRUMENT. THESE GASES CAN BE HARMFUL AND/OR FLAMMABLE EVEN AT LOW CONCENTRATIONS. THE ANALYZER'S EXHAUST PORT MUST BE VENTED TO A SAFE AREA. PERSONAL PROTECTIVE EQUIPMENT MUST BE WORN WHEN USING OR SERVICING THIS INSTRUMENT.**

**AFTER EACH USE, BEFORE TURNING OFF THE POWER OR DISCONNECTING ANY TUBING CONNECTED TO THE ANALYZER, REMOVE THE PROBE AND FLUSH THE UNIT WITH AIR FOR FIVE MINUTES**

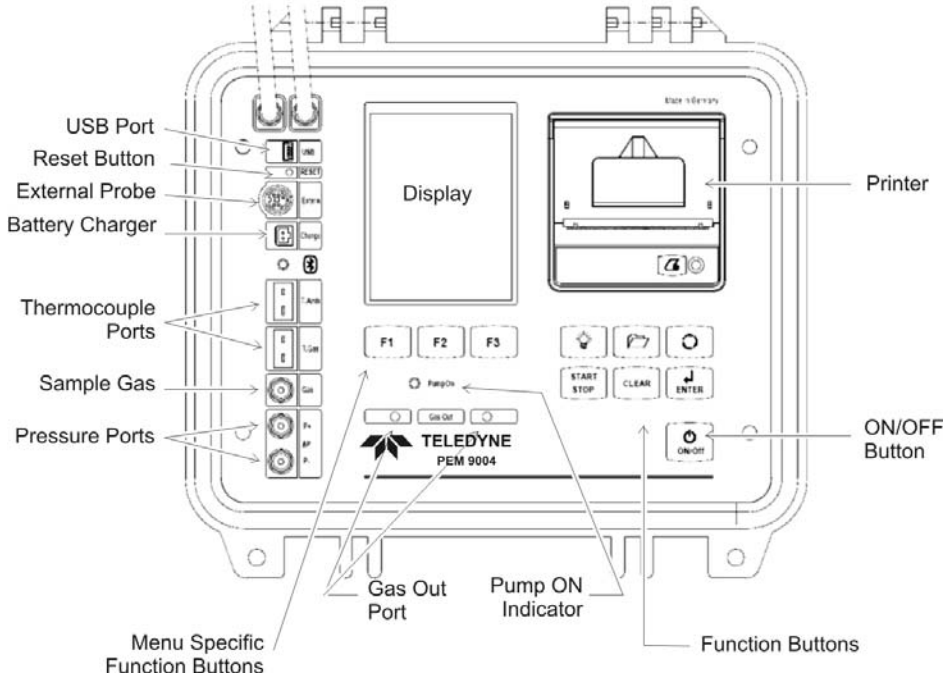



*Figure 3-1: PEM-9004 Front Panel*

## 3.3 Initial Calibration

The instrument, when first powered up will go through a self-diagnostic test routine and auto calibrate. For this reason, when

powering up for the first time or after a lengthy period of inactivity (1 week or longer) turn the analyzer on without the probe attached. Ambient air will be drawn in through the gas in port and used to set a zero reference for the sensors.

The front panel display will indicate any problems encountered during the initial calibration. It will also display the battery status using a series of 10 battery icons. Each filled battery icon indicates 10% of full charge remaining. For instance, if 7 filled batteries are indicated, the state of charge of the battery is 70%.

*Note: The initial auto calibration with the probe and thermocouples unattached will cause a temperature sensor warning. The display will indicate a T-Room Sensor and T-Gas Sensor failure. This is normal if the thermocouples are left unattached.*

## 3.4 Battery Power

The PEM-9004 has a 6V NiCad battery installed and is designed to operate only from battery power. Continuous monitoring (although not recommended) for up to 36 hours is possible from a single charge. The analyzer is equipped with a 120V 60 Hz AC battery charger for recharging the battery. The unit should be OFF when the battery charger is connected.

**CAUTION: THE ANALYZER IS NOT DESIGNED TO OPERATE IN MONITOR MODE WITH THE BATTERY CHARGER CONNECTED. USE ONLY THE 6V NICAD BATTERY TO POWER THIS INSTRUMENT.**

### *3.4.1 Charging the Battery*

When recharging is necessary, turn the instrument OFF and connect the charger to the instrument at the port labeled CHARGE. Connect the power end of the charger to 120VAC 60 Hz power source or 220VAC 50/Hz depending on your model.

The service life and capacity of the battery are considerably affected by the way the instrument is charged and used. In order to make handling safer, the instrument has a load management unit.

The load management feature is responsible for maintaining the state of charge of the battery and monitors the temperature of the battery

when charging. If a NiCad battery is always charged from 80% to 100% i.e. the state of discharge of the battery never falls below 80% before the battery is recharged, the battery will lose some of its capacity. This is called “memory effect” and is a well-know problem in rechargeable batteries. The battery remembers to what extent it is run down.

A part of this memory effect is suppressed by the load management unit. It senses the state of discharge of the battery and will not allow recharging until battery capacity has dropped below 60%.

Constant overcharging has adverse effects on the NiCad battery as well. The load management feature monitors the state of charge, the voltage, and the battery temperature. When predefined limits are exceeded, the charging process is interrupted. After the appropriate parameters are restored, the charging process is automatically restarted.

The service life of the NiCad battery can be significantly reduced when the instrument is operated at temperatures below 40°F (5°C).

The graphic charge level indicator on the front panel display is comprised of 10 battery symbols and is located in the one-line status display during the calibration phase. The PEM-9004 load management unit continuously monitors the incoming and outgoing current during operation and charging. Under normal operating conditions, the instrument should be operated until the battery is completely run down (10 empty battery icons as opposed to dark, filled icons). When this is routinely followed, the actual capacity of the NiCad battery is accurately shown on the display.

### *3.4.2 Battery Replacement*

Contact factory for battery replacement

## 3.5 Sensor Replacement

Up to 5 electrochemical cells are installed in the PEM-9004 analyzer depending on the options ordered. When new cells are ordered, they are packaged in a controlled atmosphere. The instrument is shipped with the required sensor cells installed.

# Operation

## 4.1 User Interface

Operation of the PEM-9004 is accomplished entirely from the front panel using the 7 function keys on the right plus the 3 menu select keys below the screen. The menu select keys take on additional functions depending on the menu context. Figure 4-1 shows the location of the function and menu select keys. Table 4-1 identifies each function key and provides a brief description of its use.

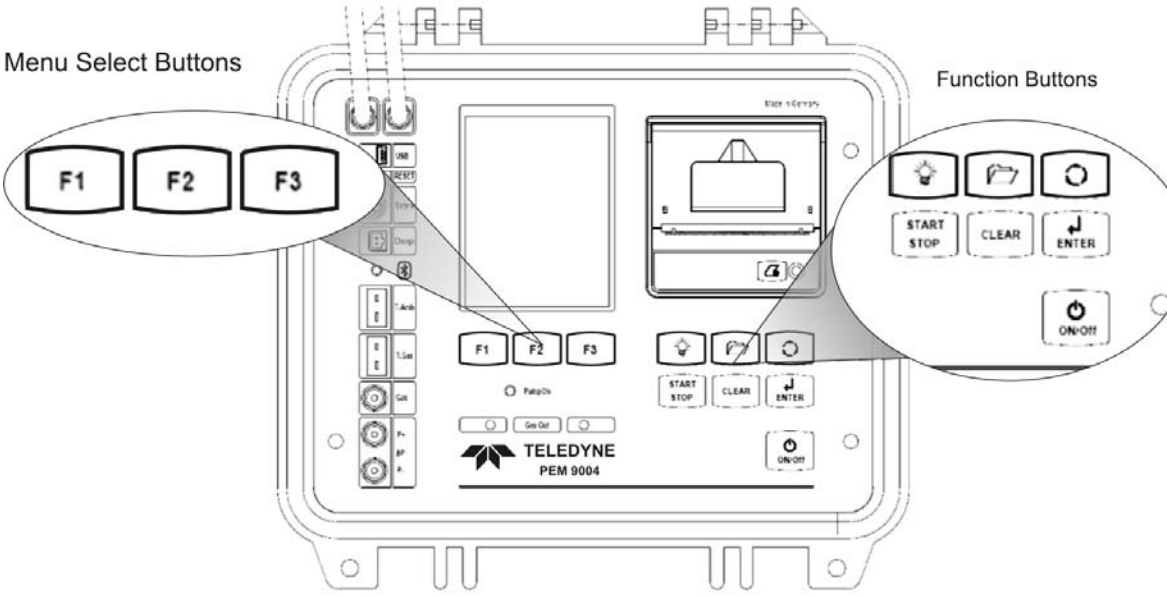



*Figure 4-1: PEM-9004 Front Panel*

*Table 4-1: Function Keys*

| Key | Function | Action |
|---|---|---|
| ON/OFF | ON/OFF switch | Switches the power on or off to the instrument. |
| | Backlight key | Turns the display backlight on or off. |
| | Change layout | Used to alter the layout of the menu specific F1, F2, and F3 keys. |
| | Change display | Alters line by line the way the display is arranged. |
| START STOP | Pump ON/OFF switch | Turns the gas feed pump on or off. |
| CLEAR | Clear key | Close/cancel/reset a function, menu or display item. |
| ENTER | Enter key | Confirms an entry or action. |

The function buttons are used to select specific options from the displayed menu. Some menus have numerous options to select from such as the Flue Gas menu shown in Figure 4-2. In this case the function buttons (F1, F2, F3) will correspond to the functions on the selected line. For instance, if line 3 is selected by scrolling down with the "Change Layout" key (🗁), then pressing F1 will select the "Save" function, F2 will select "Draught detection", and F3 will select "CO protect".

Note that the screen display will list: "Save", "Draught detection" and "CO protect" instead of F1, F2, and F3.

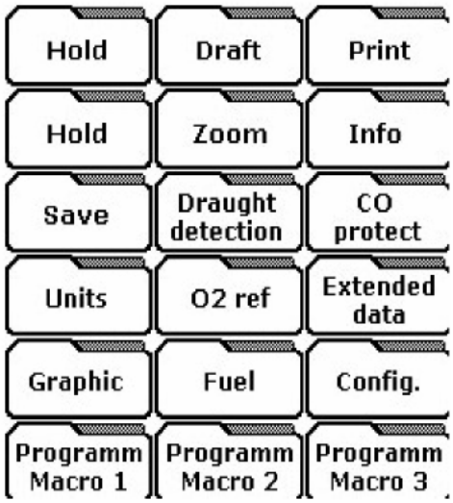
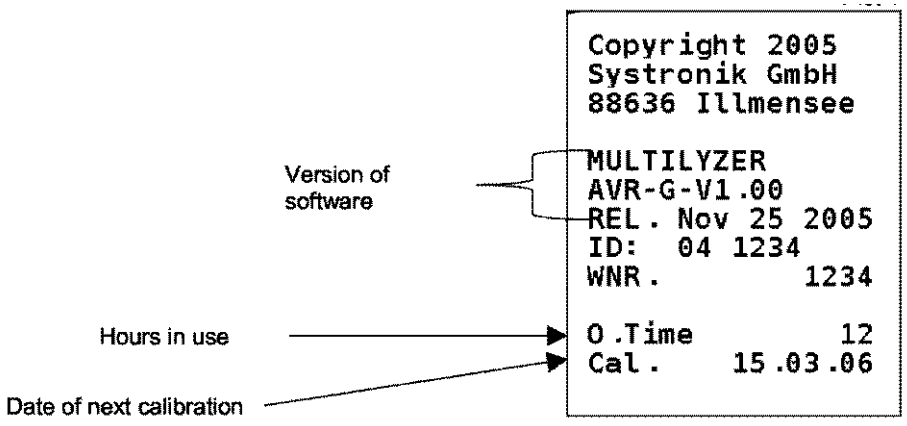



*Figure 4-2: Additional Functions Available from Flue Gas Menu*

## 4.2 Startup Screen

- Press the ON/OFF button to turn the instrument ON.

  The screen that appears includes information about the version, part-no., hours in use, etc. This initial startup screen is shortly replaced by the Main menu screen.



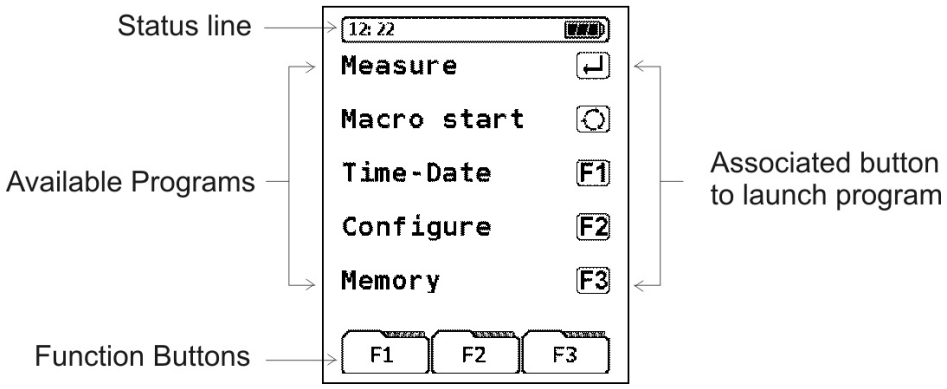

- To hold this initial screen on the display press the ENTER button during the startup routine.

- Press the CLEAR button to close it.

You can switch the backlight on/off using the backlight button) but the other buttons have no function in this initial menu.

## 4.3 Main menu

The Main menu screen appears automatically after the initial startup screen. The Main menu includes a status line and a list of available programs associated with the 3 function buttons.




### *4.3.1 Status Line*

The status line appears at the top of most screens and continuously updates and displays the status of certain information such as remaining battery power, HOLD-function, sensor-alerts, operation of the pump, chosen fuel, time, etc. It is context sensitive and depends on the presently displayed screen.

### *4.3.2 Available Programs*

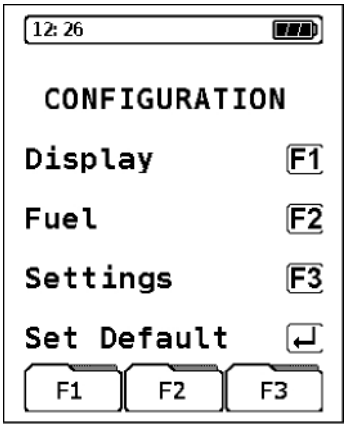
Below the status line is a list of available programs accessible from the Main menu. Each program is launched by the appropriate button indicated to the right of the program name. In most cases additional menus and additional screens will be available from within the selected program.

## 4.4 Configure Menu

The Configure menu is used to set up the analyzer for your specific process. From this screen you can:

- Change the display order so that the information on the screen is in a convenient sequence.
- Select a specific fuel from a list or add a new fuel to the list.
- Change the general settings of the instrument.
- Return to the default configuration of the instrument.

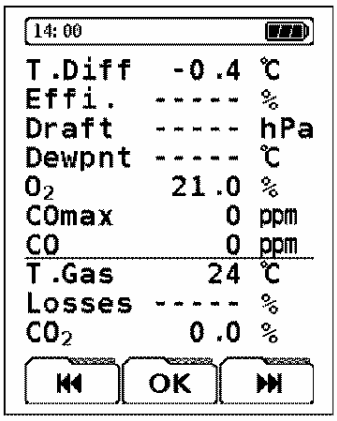
To enter the Configure menu press the F2 key from the Main menu. The following screen appears:



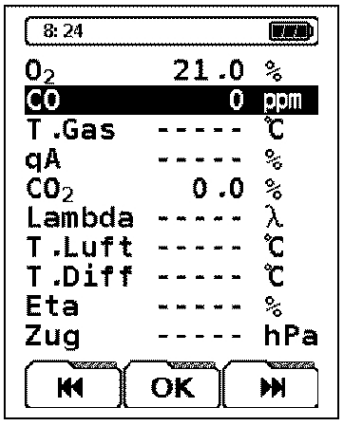

### *4.4.1 Display*

The sequence of the measured or calculated parameters can be repositioned in any way to suit your preference. This is accomplished from the Display screen. To rearrange the measurement screen:

- From the Configuration menu press F1 to bring up the Display screen. The following screen appears:




- Use the arrow keys to move the underline cursor to the line you want to move. Then press OK to activate the line for repositioning.
- Move the selected line up or down using the arrow keys. When it is in the chosen position, press OK. The following screen shows the CO measurement line repositioned to the second line from the top.

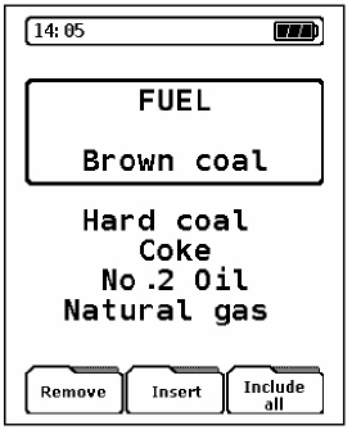



- Press ENTER to save the setting or CLEAR to cancel the move.

*Note: The same line cannot be displayed more than once.*

### *4.4.2 Fuel*

The Fuel menu is used to add or remove a fuel from the list of available fuels stored in the analyzer's memory. Up to five additional fuels can be configured and stored in the list. To enter the Fuel menu press F2 from the Configuration menu. The following screen appears:




From this screen you can remove a fuel from the list, add a fuel to the list or include all the fuels programmed into the analyzer memory including those that have been removed.

#### 4.4.2.1 REMOVE A FUEL FROM THE LIST

- Press the button corresponding to "Remove". The fuel that is highlighted in the frame will be removed from the list.

*Note: The removed fuel can be reinstated using the "Include all" function.*

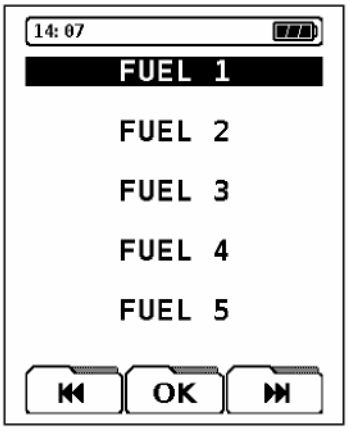
#### 4.4.2.2 REINSTATE A PREVIOUSLY REMOVED FUEL

- Press the button corresponding to "Include all". Any previously removed fuel will be reinstated in the fuel list.

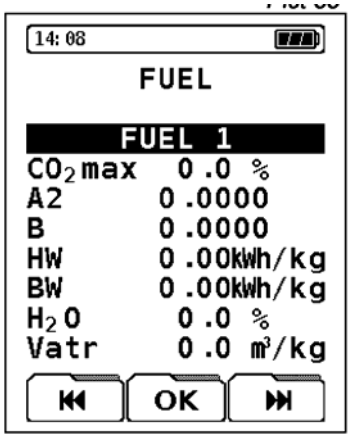
It is possible to add up to 5 additional fuels to the preinstalled list of fuels. In order to create a new fuel the first three fuel-specific factors ($CO_{2max}$, A2 and B) have to be entered. If units than ppm or % are used additional factors must be entered in order to perform the conversion to $mg/m^3$, mg/kWh or $MJ/m^3$ correctly.

#### 4.4.2.3 INSERT A NEW FUEL

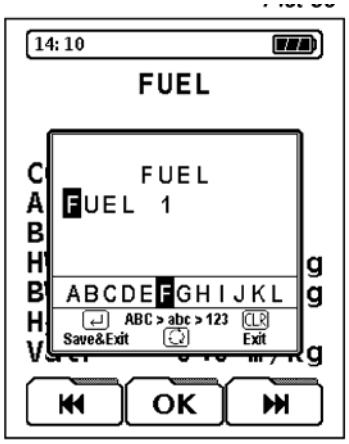
- Press the button corresponding to “Insert”. The following screen appears:




- Use the arrow buttons to select where you want the fuel to be added (Fuel 1, Fuel 2 . . . etc.). Press OK when the proper location is highlighted. the following screen appears:




Press OK again to enter the editor screen. From this screen you can enter or edit the name of the fuel.




- Use the arrow keys to scroll to the appropriate character and then press OK to accept the letter. The character will appear on screen and the position marker incremented to the next letter position. If you make a mistake, continue pressing the OK button until the cursor returns to the letter in error. Then reselect the appropriate character using the arrow keys and press OK once again to accept the new character.
- Use the cycle button to toggle between all capital letters, lower case and numerical input.
- When the fuel name has been entered, save the input by pressing ENTER or cancel the input by pressing CLEAR.

Once the fuel name has been input and accepted, the fuel properties can be entered in the same fashion. Use the arrow keys to scroll the highlighted line to the parameter you want to input and press OK. Repeat the above procedures for editing each parameter required to specify the fuel. The parameters include:

$CO_{2max}$

A2

B

HW (heating value without condensation)

BW (heating value with condensation)

$H_2O$ (water content)

Vatr (quantity of fuel gas, dry)

### *4.4.3 Settings*

The Settings screen is used to set the following instrument parameters:

- Units used for draft and pressure
- Sound off/on
- Printer
- User address
- Automatic shut down of the instrument and display illumination

Pressing F3 from the Configuration menu brings up the Settings screen.

#### 4.4.3.1 UNITS FOR DRAFT AND PRESSURE

- Use the cycle button to highlight the Draft/Press line on the screen.
- Use the arrow keys to toggle between the available units. When the desired unit appears, press OK.

#### 4.4.3.2 INSTRUMENT SOUND ON/OFF

- Use the cycle button to highlight the Sound line on the screen.
- Use the arrow keys to cycle between Yes (ON) and No (OFF).
- Press OK to save the setting.

#### 4.4.3.3 SELECT PRINTER

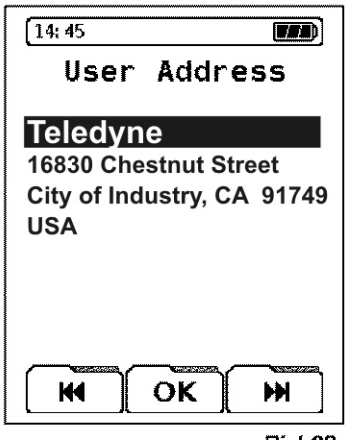
Two printers are available in the the PEM-9004: EUROprinter (Euro-Ir) and HP84420B (HP-Ir). To select the printer to use:

- Use the cycle button to move the highlight to the Printer line.
- Use the arrow keys to toggle between Euro-Ir and HP-Ir. When the correct printer appears, press OK.

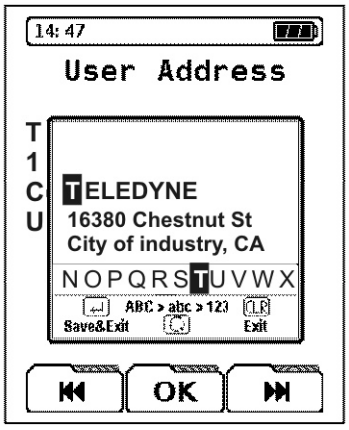
#### 4.4.3.4 USER ADDRESS

The User address can be included in various reports printed by the analyzer. To enter the user address:

- Use the cycle button to highlight the User Address line on the screen. Press OK and the following screen appears:




- Use the arrow keys to move the highlight to the line you want to edit. Press OK and the edit window appears.



- Use the arrow keys to select the character to enter then press OK. The cursor moves to the next position. Repeat the process to enter or edit the correct address line. Each line is entered separately. When the line is correct, press ENTER to save the result or CLR to cancel the input. The editing screen disappears.

*Note: The cycle key can be used to toggle between caps, lower case and numerical input.*

- Use the arrow keys to move the highlight to the next line for editing. Press OK and the editing window opens. Repeat the above procedure to enter the user address line by line pressing ENTER after each line is completed.
- After the final line is entered and saved you will be returned to the Settings screen.

#### 4.4.3.5 AUTOMATIC TIMER

The PEM-9004 is equipped with automatic timers that will turn off the display illumination and/or shut the instrument off to conserve battery power. Both automatic features operate independently and initiate if no key press is detected within the user-specified intervals.

To set the automatic power off feature:

- Use the cycle button to highlight the Auto Off line on the screen then press OK.
- Use the arrow keys to increase or decrease the interval. Press ENTER to save the setting or CLEAR to cancel the input.

*Note: The Auto Off interval can be set in 5 minute intervals from 0 to a maximum 60 minutes.*

*The automatic shut off feature is disabled if an interval is set to 0 minutes.*

To set the automatic backlight off feature:

- Use the cycle button to highlight the Illum. Off line on the screen then press OK.

- Use the arrow keys to increase or decrease the interval. Press ENTER to save the setting or CLEAR to cancel the input.

*Note: The Illum Off interval can be set from 0 to a maximum of 30 seconds in one second intervals.*

*The automatic illumination off feature is disabled if an interval is set to 0 seconds.*

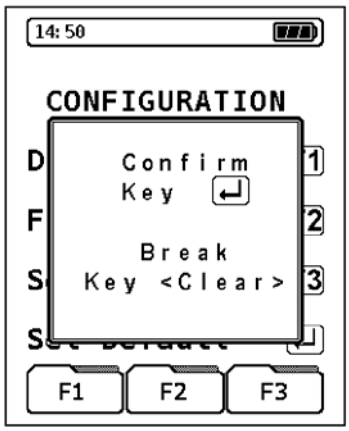
### *4.4.4 Set Default*

The Set Default function is used to return the instrument to the initial factory programmed settings.

**CAUTION: RESTORING THE INSTRUMENT TO FACTORY DEFAULT SETTINGS WILL RESULT IN THE LOSS OF ALL INDIVIDUAL SETTINGS AND CANNOT BE UNDONE EXCEPT BY REENTERING THE USER SETTINGS! THE DATA MEMORY IS NOT AFFECTED.**

To restore the instrument to the default settings:

- Press ENTER from the Configuration Main menu. The following screen will appear:




- Confirm the restoration operation by pressing ENTER or cancel the request by pressing CLEAR.

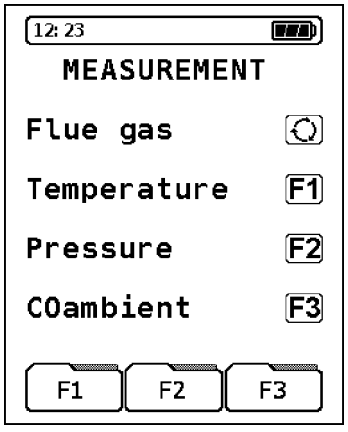
## 4.5 Measurement Screen

The Measurement screen is the main operation mode of the instrument. It allows you to calibrate the specific flue gas for measurement, perform gas measurements and calculations, and perform pressure and temperature measurements.

In the Measurement menu the following button combinations are available:

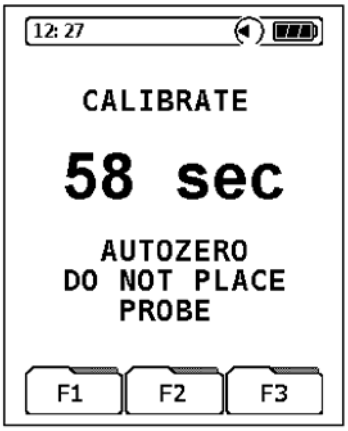
| | |
|---|---|
| Cycle: | Scroll line by line or toggle between available options. |
| Change Layout: | Change the layout of the function buttons. |
| Gas pump: | Turn the sample gas pump on or off. |
| Backlight: | Turn backlight on the display on or off. |
| Reset CO2max-value: | Enter a new value for the $CO_{2max}$ value (fuel specific). |

To enter the Measurement screen press ENTER from the Main menu. The following screen appears:



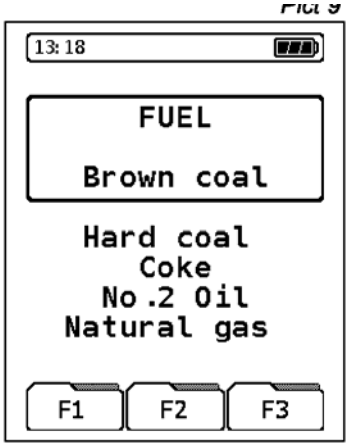
### *4.5.1 Flue Gas*

To calibrate the instrument on a specific flue gas or change the current flue gas, press the cycle button from the Measurement screen. The following screen appears:




The instrument begins an automatic calibration cycle which takes approximately 60 seconds from a cold start. If a restart is performed from the Measurement screen, the calibration process only takes 10 seconds. The instrument probe should not be attached during this calibration.

After the calibration the last used fuel appears on the screen as shown below.




At this point, either the fuel in the framed box can be chosen or any another fuel from the database of fuels in memory. The selected fuel has to be in the framed box.

- If the correct fuel is displayed, press ENTER to confirm the selection.
- If it is not correct press the cycle button to cycle through the internal list of fuels.
- Press ENTER when the desired fuel is displayed.

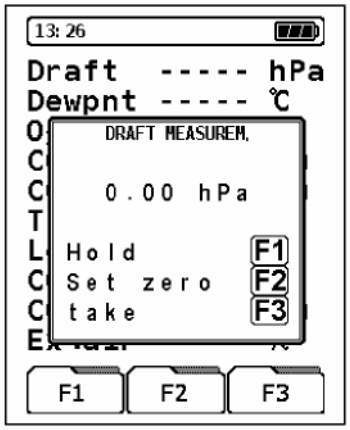
Once a fuel has been selected, a range of other functions are available and assigned to the F1, F2, F3 function buttons as shown in Figure 4-2.

Use the cycle button to scroll line by line through the available functions. Note that the on screen representation of F1, F2 and F3 change appropriately to the named function.

It may be more convenient to alter the position of some functions so that they appear on the same line. For instance, if you routinely change fuels, make a measurement then , print and save the data, it may be more efficient to have “fuel”, “print”, and “save” buttons on the same line to avoid having to constantly scroll back and forth to the various lines. Use the Change Layout button to move all three functions to the same line.

#### 4.5.1.1 DRAFT

This button is used to start a draft measurement. When pressed, the following screen appears:




Hold (F1): Holds the reading for the draft measurement.

Set Zero (F2): Performs a zero calibration.

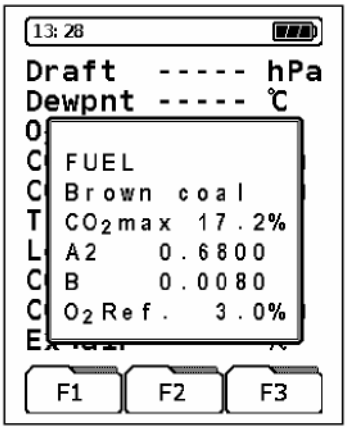
Take (F3): Transfers the draft value to the Flue Gas menu.

*Note: To determine the zero point in relation to the surrounding air pressure, unplug the air tube (with the blue connector) before every draft measurement. Then press the F2 button and connect the air tube again.*

Cycle button: Scroll line by line through the available functions within the Flue Gas menu.

#### 4.5.1.2 INFO

Pressing the Info button launches the Info screen which displays important fuel parameters, current sensor status and the $O_2$ reference value.

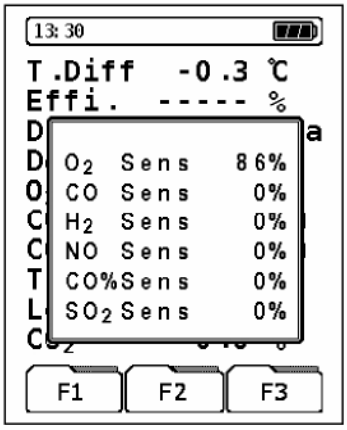



Function buttons active in this menu are:

Cycle: Change values in the various fields.

Change Layout: Opens the sensor status screen as shown below.

CLEAR: Close the Info screen




### Sensor quick-diagnosis:

$O_2$-value > 50 %

Oxygen cell OK

CO- and $H_2$-value: 0 to 1 %

CO-sensor with 1-12-compensation OK*

CO%-value: 0 to 1 %

CO-sensor for upper range OK*

NO- and/or $SO_2$-value: 0 to 1 %

NO- and/or $SO_2$-value OK*

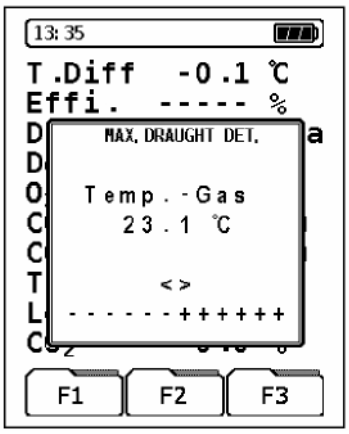
* indicates the respective sensor option is disabled.

*Note: If any other values are displayed, the corresponding sensor is either in need of service or the electrolyte is depleted.*

#### 4.5.1.3 DRAUGHT DETECTION

The function "Draught detection" displays the flue gas temperature graphically. Changes in the temperature of the flue gas are shown with a black bar. No bar appears if the temperature is constant.

Press the Draught Detection button to open the Draught Detection screen.



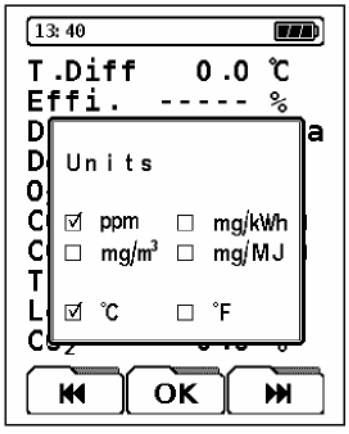

Draught detection is only available for the measurement of the flue gas temperature in the Flue Gas menu.

Function buttons active in this menu are:

| | |
|---|---|
| Cycle: | Change representation of readings in the Main menu line by line. |

#### 4.5.1.4 UNITS

The PEM will automatically convert units to the specified type as determined from the Units menu. Press the units button to display the Units screen.




- Use the arrow keys to select the desired units.
- Press OK to confirm the selection.

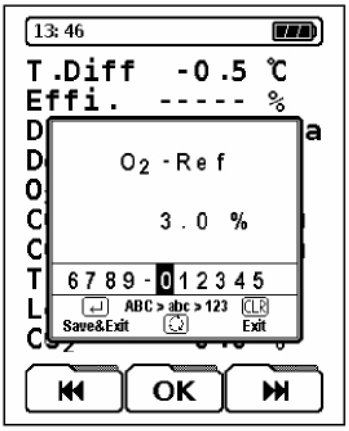
- Press ENTER to save the unit selection or CLEAR to cancel the operation.

The data on the Flue Gas screen will be converted and updated to the selected units. The units will remain in use until another unit is selected.

#### 4.5.1.5 $O_2$ REFERENECE

In some instances in order to correctly convert the measured gas values it may be necessary to modify the $O_2$ reference value. For gas and oil fuels a value of 3% is preset. For solid fuels a value of 13% is preset.

To change the $O_2$ reference value, press O2 Ref from the Flue Gas menu. The following screen will appear:



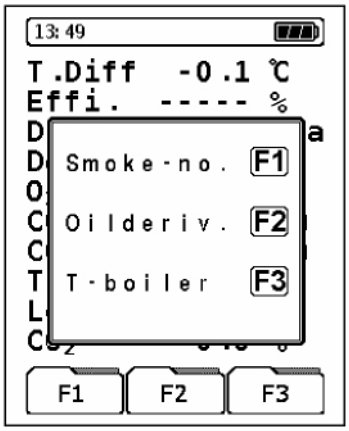

- Use the arrow keys to select the desired digit.
- Press OK to confirm the selection.
- Press ENTER to save the new value selection or CLEAR to cancel the operation.

#### 4.5.1.6 EXTENDED DATA

The following data can be entered and transferred to the measurement protocol:

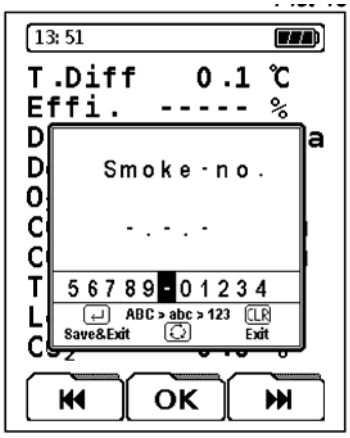
- Smoke-no. (soot content according to the Bacharach scale).
- Oil derivatives.
- Temperature of boiler and heat carrier.

To enter the data, press the Extended Data button from the Flue Gas menu. The following screen appears:




### Smoke-no. input menu

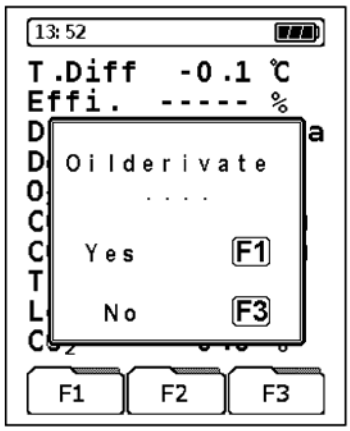
The value that was determined through the mechanical soot pump can be entered using the function button F1.The following screen appears:




- Use the arrow keys to select the desired digit.
- Press OK to confirm the selection.
- Press ENTER to save the new value selection or CLEAR to cancel the operation.

### Oil derivatives input menu

Pressing F2 from the Extended Data menu displays the Oil Derivates Input screen. In this screen there is a choice between "Yes" (oil derivatives exist) and "No" (no oil derivatives exist).

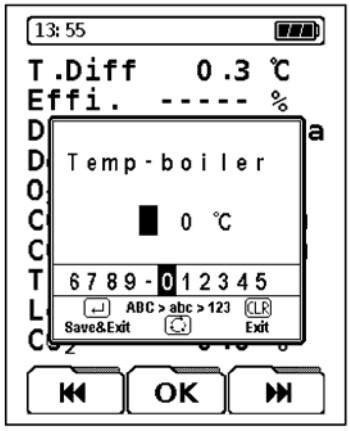



- Press F1 if oil derivatives are present.
- Press F3 if oil derivatives are not present.
- Press ENTER to save the result or CLEAR to cancel the operation.

### Temperature and heat carrier

Pressing F3 from the Extended Data menu displays the Boiler Temperature screen. In this screen, the measured temperature can be entered through the editor.

- Use the arrow keys to select the desired digit.
- Press OK to confirm the selection.
- Press ENTER to save the entered temperature or CLEAR to cancel the operation.

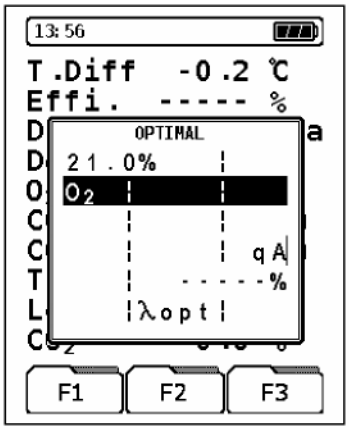



*Note: When the input menu for the extended data (Smoke-no., oil derivatives and boiler temperature) is closed all data that has been confirmed with the ENTER button will be stored in the measurement protocol. Inputs of data that have been cancelled will be discarded.*

#### 4.5.1.7 GRAPHIC

The Graphic function uses a graphical display to show the numerical values according to the chosen fuel. The remaining content of oxygen ($O_2$) and the calculated waste gas losses (qA) are thereby set in a relation to the excess air value ($\lambda$) and to the classical combustion diagram.

Press Graphic from the Flue Gas menu to bring up the graphic display as shown below:



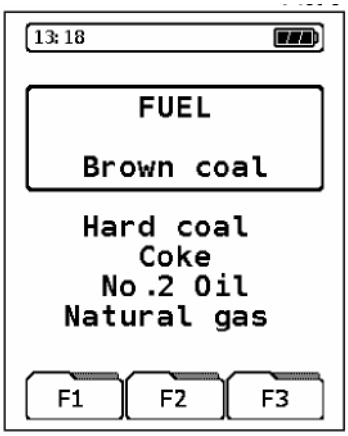
*Note: If both bars extend to the optimal fuel-air relation (the gap indicated λopt) the firing facility in question is set correctly.*

Press ENTER to close the graphics display.

#### 4.5.1.8 FUEL

The Fuel menu is used to select a fuel from the list of stored fuels in memory.

Press the button corresponding to Fuel from the Flue Gas menu. The following screen appears:




In order to select the new fuel it must appear in the framed box. To change the current fuel:

- Use the cycle button to scroll through line by line the available fuels in memory.
- When the desired fuel appears in the framed box, press ENTER or press CLEAR to abort the operation and return the previous fuel. Pressing either ENTER or CLEAR returns the display back to the Flue Gas menu.

#### 4.5.1.9 CONFIG

See Section 4.4.

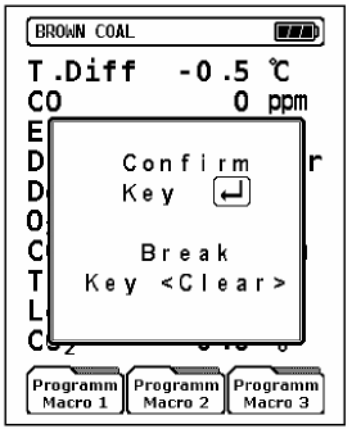
#### 4.5.1.10 PROGRAM MACROS

Up to three customized measuring configurations can be created and stored as programmed macros. These macros can be started directly

from the Main menu. The operation of these macros can be reduced to a few button inputs only.

Program macros can have configurations as shown below:

- Order of the readings that are shown on the screen
- Font size of the readings (5 or 10 characters)
- Predefined fuel
- Preset measuring units




To enter a programmed macro:

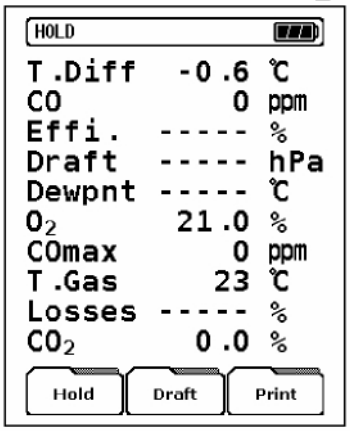
- Set the configuration to the desired state
- Press Macro 1, Macro 2 or Macro 3 to inform the instrument which button is to be assigned the macro configuration.
- Press ENTER to save the configured macro to the assigned macro button or CLEAR or abort the operation.

#### 4.5.1.11 HOLD

The Hold function is used to temporarily freeze the screen keeping the measured data from changing, When the HOLD function is activated all displayed measured data at the time the button was pressed will be kept.

*Note: When the HOLD function is activated the alert "HOLD" appears in the top left corner of the status line replacing the name of the fuel.*

To initiate a Hold, press Hold from the Flue Gas menu. The following screen is representative of a hold screen:




#### 4.5.1.12 ZOOM

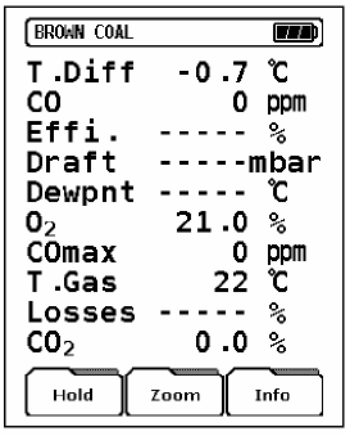
The Zoom function is used to change the displayed font size and the number of lines capable of displaying on a single screen.

There are two fonts and therefore types of layout available:

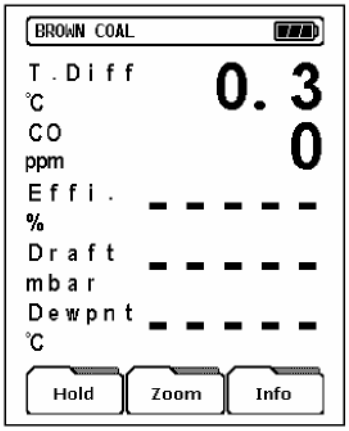
- 10-line layout
  The 10-lines layout is the default layout set at the factory. Measured parameters are shown on the left whereas readings and units are shown on the right.
- 5-line layout
  This layout reduces the number of displayed lines and increases the font size to facilitate the reading of the display from a greater distance. In this layout, measured parameters and units are on the left and readings only are on the right.

The zoom button toggles the screen display between the two layouts as shown in the following screen displays.

*Note: After the device is switched off and on again, the display resets to the 10-lines layout automatically unless the 5-lines layout was a measurement configuration activated by a macro.*




*10-Line Layout*




*5-Line Layout*

#### 4.5.1.13 CO PROTECT

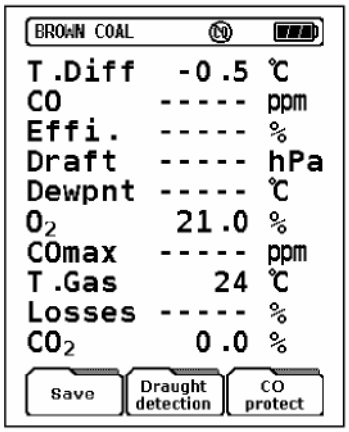
The PEM-9004 is equipped with a second pump (CO-flushing-pump) in order to protect the sensitive CO-sensors from CO-overload.

The CO-flushing-pump switches on automatically when necessary, i.e. when the admitted CO-range is exceeded or it can be switched on manually using the CO Protect button.

When the CO Protect button is pressed the CO pump will start. Pressing CO Protect button again will turn the pump off as long as the

CO concentration is below a factory preset threshold the value of which depends on the sensor installed.

Whenever the CO pump is on (whether it is started automatically or manually) a scored out CO-symbol appears in the status line as shown in the screen display below.




.

If the CO-flushing-pump starts automatically due to an excess concentration of CO it cannot be switched off manually until the CO-concentration falls below a factory preset value.

Once the CO-concentration has reached the lower range the CO-flushing-pump will automatically shut off.

If the analyzer is equipped with two CO-sensors the result of the higher range sensor will be displayed when the lower range sensor is flushed.

The active CO-flushing-pump has no influence on any other sensors within the analyzer.

#### 4.5.1.14 PRINT

The measured data can be printed out by means of a wireless infrared printer.

The printer in use can be selected from the Configuration menu. See Section 4.4.3.3. The print speed depends on the printer selected. Make sure the proper printer is activated to avoid possible failures while printing.

The PEM-9004 is capable of multi-tasking so the analyzer can be taking measurements, performing calculations, etc during the printing procedure. Printing takes place simultaneously in the background as other analyzer operations are being performed.

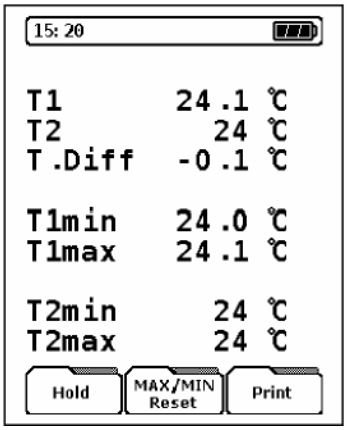
To print a screen, press the Print button from the Flue Gas menu.

### *4.5.2 Temperature*

The temperature program can be started by pressing F1 from the Measurement screen.

The PEM-9004 supplies two temperature measurement channels (T1 and T2). Measurement channel T1 is displayed with a resolution of 0.1°C whereas channel T2 has a resolution of 1°C.

The Temperature screen is shown below:

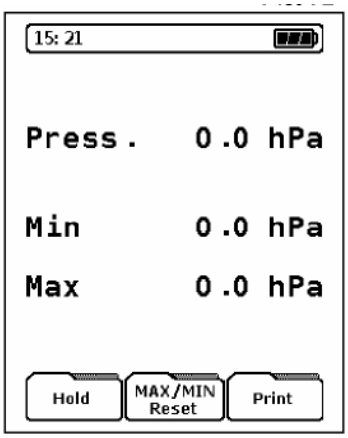



Available functions from within the temperature program are:

| | |
|---|---|
| Hold: | Freezes the current temperature readings. |
| Max/Min Reset: | Resets the current temperature readings. |
| Print: | Prints out the currently displayed temperature screen |
| Cycle button: | Change units (°C or °F). |

### *4.5.3 Pressure*

The pressure program can be started by pressing F2 from the Measurement screen.




Available functions from within the pressure program are:

| | |
|---|---|
| Hold: | Freezes the current pressure readings. |
| Max/Min Reset: | Resets the current pressure readings. |
| Print: | Prints out the currently displayed pressure screen |
| Cycle button: | Change units (°C or °F). |
| ENTER button: | Reset the pressure to zero. |

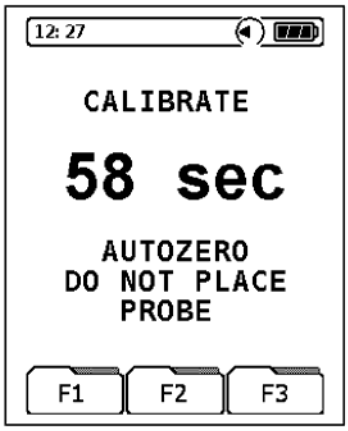
The following units for pressure can be selected:

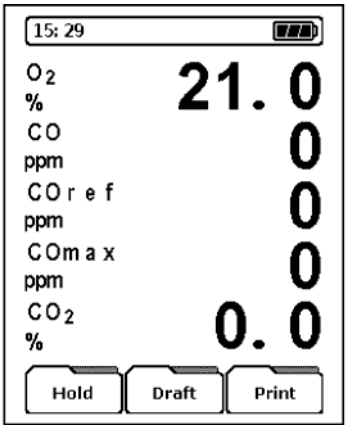
hPa,
mbar,
mmWC (millimeter water column)
mmHg (millimeter mercury column)
inWC (inches water column)
inHg (inches mercury column)
Psi (pounds per square inch)

The conversion takes place in the active measurement program as well as in the HOLD-mode.

### *4.5.4 CO ($O_2$) Measurement*

This is a reduced measurement (without temperature measurement) for analyzing the flue gas. For this measurement program the same keypad functions apply as described in Section 4.5.1 *Flue Gas* except that the number of readings is reduced to five significant flue gas values.




The font size of the readings can be changed with the Zoom function. See Section 4.5.1.12 *Zoom*.

## Important notice concerninq measurement of S02 and N02 (option)

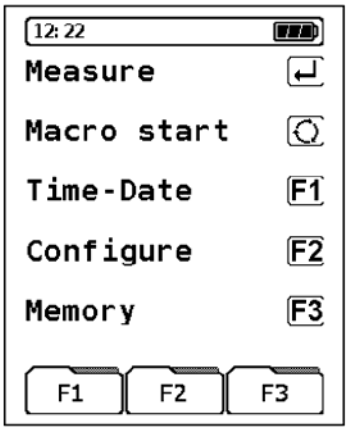
$SO_2$ and $NO_2$ gases have a high solubility in water. For measurement of $SO_2$ and $NO_2$ concentrations it is necessary to remove the condensate residues form the gas filtration and drying system. These residues can absorb $SO_2$ and $NO_2$ which could cause erroneous measurements.

Furthermore, when carrying out $SO_2$ and $NO_2$ relevant measurements no additional desiccant should be used. Even when dry the dessicant can absorb a significant amount of $SO_2$ and $NO_2$.

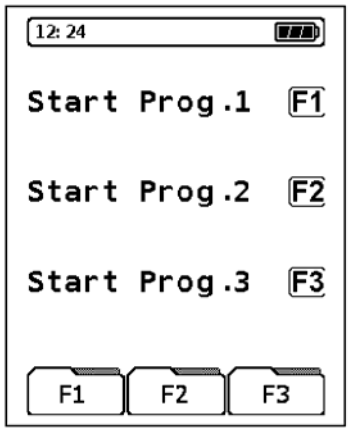
## 4.6 Macro Start

The Macro Start function launches configuration settings previously programmed and saved as a macro. See Section 4.5.1.10.

Macros greatly facilitate the efficient operation of the PEM-9004 by loading and initiating convenient configuration settings using only a few keystrokes. Up to three customized macros can be programmed and used.




To launch a previously saved macro call the Macro Start function by pressing the cycle button from the Main menu.




Press F1, F2, or F3 to start a previously programmed and saved macro.

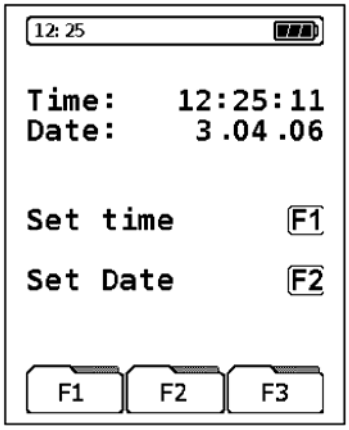
When the macro is launched, the macro the settings it is based on will be activated automatically after the calibration phase and without displaying the list of fuels.

If a Set Default operation (restore default settings) is carried out, all macro-settings will be lost. See Section 4.4.4. Without customized settings, the settings for the fuel gas analysis will be used.

## 4.7 Time-Date

The integrated clock (time and date) can be set from the Time-Date screen available from the Main menu.

To set the time and date, press F2 from the Main menu. The following screen will appear:



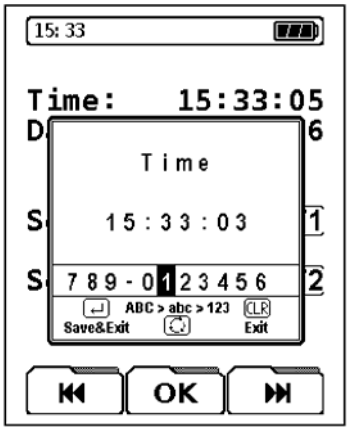

The time will be displayed in the top left corner of the status line if not replaced by an alert or other superimposed information.

Time and date will be saved together with the corresponding data and will appear on any print-outs of the measured data.

*Note: The time value will not automatically adjust for daylight savings changes but the date value will account for leap years.*

**To set the time:**

- Press F1 from the Time-Date screen. The following screen will appear:



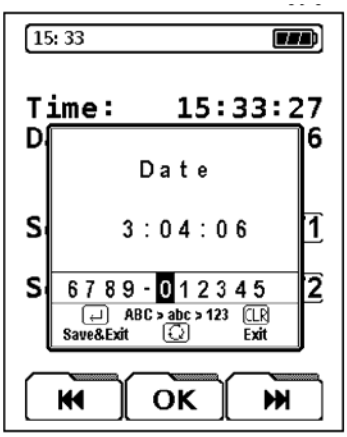

- Use the arrow keys to select the desired digit.

- Press OK to confirm the selection and move to the next digit.
- Press ENTER to save the entered time or CLEAR to cancel the operation.

*Note: While setting the time, the clock in the editor window will be stopped and will not restart until the new time is confirmed.*

**To set the date:**

- Press F2 from the Time-Date screen. The following screen will appear:




- Use the arrow keys to select the desired digit.
- Press OK to confirm the selection and move to the next digit.
- Press ENTER to save the entered date or CLEAR to cancel the operation.

## 4.8 Memory

The data memory is structured according to the menu structure shown in Figure 4.3.

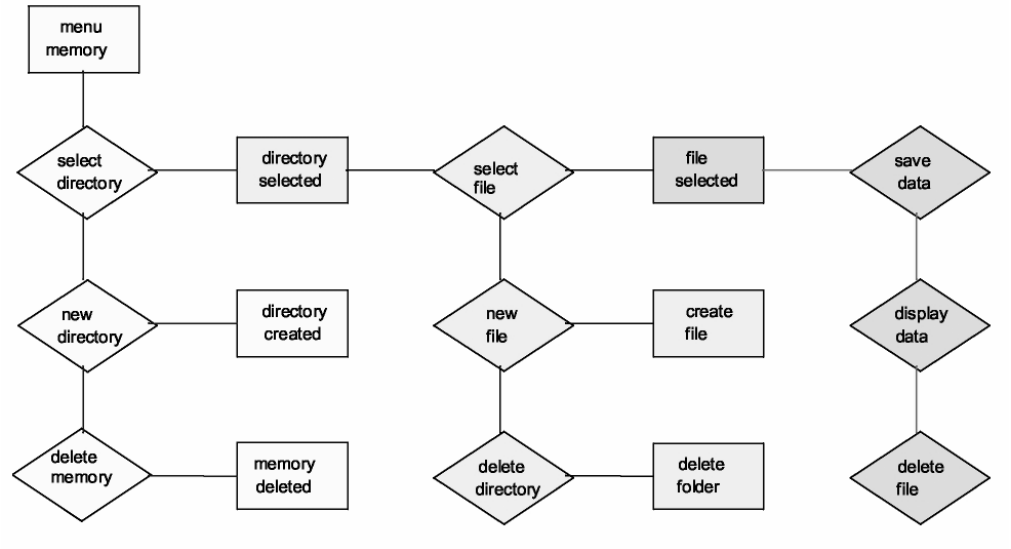


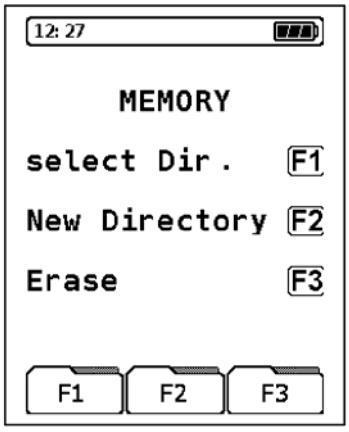

*Figure 4-3: Data Memory Structure*

The organization of the memory is dynamic, i.e. only already existing directories and files are available for saving data. Additional directories and files can be created at any time.

Names of both directories and files can be defined by the user. Directories could for instance be used for the names of clients or facilities (or client numbers). Files could be named after the types of measurement.

The PEM-9004 instrument is shipped without preset directories and files.

Memory is accessed from the Memory menu available by pressing F3 from the Main menu. The following screen appears:




From this menu you can:

- Open an existing directory (F1)
- Create a new directory (F2)
- Erase an existing directory (F3)

To save a file to memory it must be saved to an existing directory. To save a file to an existing directory:

- Press F1 to bring up a list of available directories.
- Use the arrow keys to move to the desired directory.
- Press OK. The standard editor window will appear.
- Use the arrow keys to select the character or digit. Use the cycle button to toggle between all capital letters, lower case and numerical input.
- Press OK to accept the character and move to the next position.
- When the file name is correctly entered, press ENTER to save the file or CLEAR to quit without saving.

To create a new directory:

- Press F2 to open the directory editing window.
- Use the arrow keys to select the character or digit. Use the cycle button to toggle between all capital letters, lower case and numerical input.

- Press OK to accept the character and move to the next position.
- When the directory name is correctly entered, press ENTER to create and save the directory or CLEAR to quit without creating the directory.

To erase and existing file or directory:

- Press F3 from the Memory menu.
- Use the arrow keys to move to the directory or file.
- Press OK to select the directory or file.
- Press ENTER to erase the directory or file or press CLEAR to abort the action.

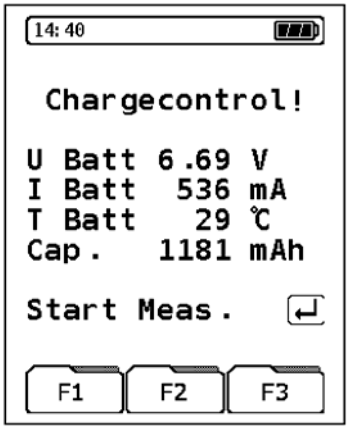
## 4.9 USB-Interface

A USB connection port is provided for special service and data communication via PC, laptop, notebook, etc. See Figure 3-1.

## 4.10 Charge Control

The battery is charged automatically when the analyzer is switched on and off after the battery charger has been connected. The battery can be recharged as well with the analyzer on. The charge control has both an active phase and a passive phase.

During active recharging, parameters related to the battery and the recharging process are displayed on the charge control screen.



U batt. = current voltage

I Bat = current amperage

T Bat = measured battery temperature

Cap. = current battery capacity

To perform a measurement while charging, press ENTER from the Charge Control menu. While in the measurement mode the battery will be recharging and continuously monitored by the system.

When the battery is fully charged, the analyzer automatically switches to the passive recharging mode (trickle charging) and the charge control screen disappears.

When active recharging is finished the charger can remain connected to the device without damaging the battery.

**CAUTION:**

**USE ONLY THE SUPPLIED OR FACTORY AUTHORIZED CHARGER UNIT FOR RECHARGING THE BATTERIES. ANY OTHER CHARGER MAY CAUSE DAMAGE TO THE BATTERY AND/OR THE ANALYZER.**

## 4.11 Battery / Line Voltage Operation

| | |
|---|---|
| Battery operation: | Maximum of 36 hours of continuous measuring (with backlight). |
| Battery charger: | 95-135 VAC 60 Hz USA version<br>200-250 VAC European version |

The analyzer employs Intelligent monitoring by means of an integrated charge-management-system. To maintain the service life and performance of the NiCd battery, please observe the following battery charging instructions.

### *4.11.1 Charging the Battery*

The PEM-9004 is equipped with an NiCd storage battery. The service life and capacity of the battery are considerably affected by the way the instrument is charged and used. In order to make the handling

safer, the instrument has an efficient battery management system unit for battery charging.

The service life of the NiCd battery can be significantly reduced when the instrument is operated at temperatures below 5°C (40 °F).

The graphic charge-level indicator of the analyzer consists of 5 elements of a battery symbol and visually informs the user of the battery status.

During normal use it is recommended not to recharge the battery until it is run down completely. The battery can be recharged at any time however, since the load management unit recognizes the charging needs of the the battery. If the battery has sufficient capacity remaining the load management unit may deny further recharging until the remaining capacity drops further.

The charge-level indicator may not accurately indicatethe true charge-level under the following circumstances:

- The device is used outside the permitted temperature range.
- The battery is old.
- Incomplete charging cycles (charging/discharging) are carried out.

If incomplete charging cycles have been used, the indicator can be corrected by discharging the batteries by switching on the device until it runs out of battery power and switches off automatically. Then connect the device to the charger and start the charging function (recharging completely takes approx. 5 hours, depending on the ambient temperature). After active recharging is complete, the PEM-9004 will switch off automatically. This "reconditioning cycle" can be repeated as often as necessary.

### *4.11.2 Battery Replacement*

For replacement of a used or dead battery, the analyzer must be returned to the factory or authorized service facility.

# Maintenance

## 5.1 Routine Maintenance

Aside from normal cleaning and checking for leaks at the gas connections, routine maintenance is limited to the following items:

**WARNING: SEE WARNINGS ON THE TITLE PAGE OF THIS MANUAL.**

- **Waste Gas Cleaning System**
  Refer to Figure 5-1. Empty the condensate reservoir completely after each measuring operation. Water residues within the measuring instrument will destroy the pumps and sensors.

**CAUTION: A DAMAGED FILTER AND / OR IMPROPERLY INSTALLED FILTER WILL GREATLY DECREASE OR ELIMINATE THE FILTERING FUNCTION. CONTINUED USE WILL RESULT IN DAMAGE TO THE PUMPS AND SENSORS.**

- **Filter Maintenance**

  Check the micro filter for contamination. Replace if necessary.
  If the pump capacity is reduced, exchange the diaphragm filter.

- **General Maintenance**

  Make sure that threaded parts are straight when installed and tighten them moderately.
  Check O-rings for proper sealing.
  Check all connectors and fittings. Makes sure all connections are secure and leak tight for gas connections.

Remove any gas residue.

- **Storage**

  Store in a cool and dry environment at a temperature of approx. 20°C (60°F).

- **Damage:**

  Warranty obligations do not apply to damage caused by improper handling, negligence and grave external influences.

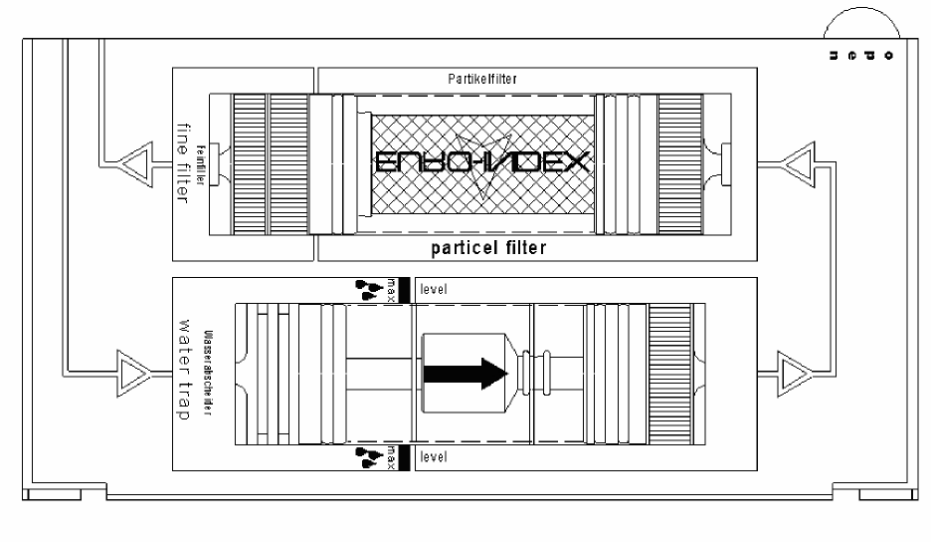



*Figure 5-1 Water Trap and Filter*

# Appendix

## Specifications

**Sensors:**

| | |
|---|---|
| **$O_2$ Measurement** | |
| Sensor: | Electrochemical, cell |
| Range: | 0-20.9 vol.% $O_2$ |
| Resolution: | 0.1 vol. % |
| Accuracy: | ± 0.2% vol. |
| Response Time (T97): | <70 sec |
| **CO2 Determination (Calculated from O2)** | |
| Sensor: | none—calculated value |
| Display Range: | 0-$CO_{2max}$ vol. % |
| Resolution: | 0.1 vol. % |
| Accuracy: | 0.2% vol. |
| Response time (T97): | <70 sec |
| **CO Measurement (with H2 compensation)** | |
| Sensor: | Electrochemical, cell |
| Measurement Range: | 0-4000 ppm |
| Resolution: | 1 ppm |
| Accuracy: | ± 5 ppm (up to 150 ppm)<br>± 5% of reading (up to 4000 ppm) |
| Response Time (T90): | <60 sec |
| **NO Measurement (Option)** | |
| Sensor: | Electrochemical, electrochemical cell |
| Measurement Range | 0-2000 ppm |
| Resolution: | 1 ppm |

| | |
|---|---|
| Accuracy: | ± 5 ppm (up to 150 ppm)<br>± 5% of reading (up to 2000 ppm) |
| Response Time (T90): | <60 sec |

**CO Measurement (without H2 compensation) (Option)**

| | |
|---|---|
| Sensor: | Electrochemical, electrochemical cell |
| Range: | 0-2.0% vol (20,000 ppm) |
| Resolution: | 0.01% vol |
| Response Time (T90): | <60 sec |

**SO2 Measurement (Option)**

| | |
|---|---|
| Sensor: | Electrochemical, electrochemical cell |
| Range: | 0-2000 ppm |
| Resolution: | 1 ppm |
| Accuracy: | ± 5 ppm (up to 150 ppm)<br>± 5% of reading (up to 2000 ppm) |
| Response Time (T90): | <60 sec |

**Waste or Flue Gas Temperature Measurement**

| | |
|---|---|
| Sensor: | K-type thermocouple (NiCr-Ni) |
| Range: | + 32—1850°F (0—1000°C) |
| Resolution: | 0.1°F or °C |
| Accuracy: | ± 2°F, ± 1°C (0—400°C)<br>±0.5% of reading (up to 1000°C) |

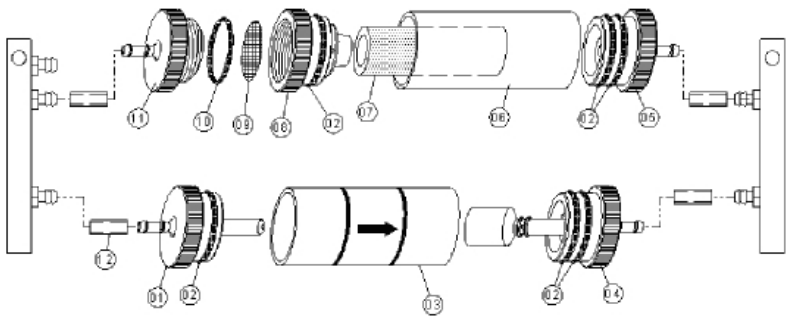
**Combustion Air or Ambient Air Temperature Measurement**

| | |
|---|---|
| Sensor: | K-type thermocouple (NiCr-Ni) |
| Range: | -5—212°F (-20—100°C) |
| Resolution: | 0.1°F or °C |
| Accuracy: | ± 2°F, ± 1°C (0—100°C)<br>± 6°F, ± 3°C (-20—0°C) |

**Draft or Pressure Measurement _____**

| | |
|---|---|
| Sensor: | Piezoresistive pressure sensor |
| Range: | ± 60 in. $H_2O$ or ± 150 hPa |
| Resolution: | 0.01 in. $H_2O$ or hPa |
| Accuracy: | ± 0.08 in. $H_2O$ or ± 0.02 hPa<br>(up to ± 8.0 in. $H_2O$ or ±2.00 hPa)<br>± 1% or reading (up to ± 80.0 in. $H_2O$/ ±20.0 hPa)<br>± 3% or reading (above ± 80.0 in. $H_2O$ / ±20.0 hPa) |
| **Power:** | NiCad storage battery 6V/4Ah with battery charger.<br>Up to 30 hours continuous operation per charge<br>On board Power Management Unit |
| **Battery Charger:** | 95-135 VAC 60 Hz USA version<br>200-250 VAC European version |
| **Display:** | LCD with backlight. 5 or 10 line display.<br>Large or small font user selectable. |
| **Gas Handling:** | Internal, with 0.8 lpm sample pump and separate purge pump, integrated gas cleaning system with water trap and filters<br>External probe with retainer cone |
| **Internal memory:** | 100 blocks available |
| **Computer Interface:** | USB standard |
| **Printer:** | Integral PIN printer |
| **Dimensions:** | |
| Housing: | 273 x 247 x 178 mm (L x W x H)<br>10.75 x 9.72 x 7 inches<br>Dustproof, waterproof |
| Weight: | Approx. 8 lbs. (3.8 kg) |
| Mechanical Connections: | 7.8mm dia. |
| Thermocouple Connectors: | Omega |

## Recommended Spare Parts List



| Replacement and spare parts | part-no. |
|---|---|
| 01 Inlet piece | 20594 |
| 02 O-Ring 23 x 2 mm | 20370 |
| 03 Glass piston with arrow mark | 20596 |
| 04 Outlet piece with cylinder | 22017 |
| 05 Outlet piece middle | 21954 |
| 06 Glass piston with logo | 20595 |
| 07 Infiltec mirco filter | 20919 |
| 08 Connection piece | 20592 |
| 09 Teflon membran 23,5 mm | 20921 |
| 11 Outlet piece | 20591 |
| 12 Silikon tube 3x2 mm | 20636 |

**Maintenance / Care**

- Empty condensate trap after use.
- Check micro filter for cntamination, replace if required.
- Exchange teflon membran filter in case of degrading pump flow.
  If damaged or inserted improdperly, the filtering function will be lost!
- Grease all O-Rings with vaseline or silicongrease as required!

A minimum charge is applicable to spare parts orders.

*Note: Orders for replacement parts should include the part number (if available) and the model and serial number of the instrument for which the parts are intended.*

Orders should be sent to:

**TELEDYNE Analytical Instruments**

16830 Chestnut Street
City of Industry, CA 91749-1580

Phone (626) 934-1500, Fax (626) 961-2538

Web: www.teledyne-ai.com
or your local representative.

## Reference Drawings

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